de maximis, inc.
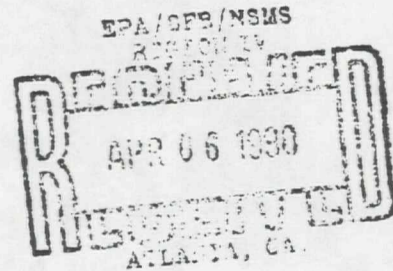
P.O. Box 90348
Knoxville, TN 37990
615-691-5052

5 April 1990

Michelle M. Glenn
USEPA Region IV
345 Courtland Street, N.E.
Atlanta, GA 30365

Subject: SCRDI-Bluff Road Site
         Remedy Selection

Dear Ms. Glenn:

As requested in EPA's letter dated March 26, 1990, the Group set forth its recommendation for the most appropriate remedy in its letter to EPA dated March 26, 1990. On several occasions, we have provided the agency with technical information demonstrating why soil vapor extraction combined with groundwater treatment is feasible for this site, and complies with all requirements of the National Contingency Plan. We believe it would be helpful to reiterate some of that information in this letter.

It should be noted that site soils do not pose a significant risk under the current or potential future use scenario and fall within the acceptable range of 1×10^{-4} to 1×10^{-6}. However, the soils have been evaluated for remediation to eliminate the source of future ground water degradation. Thus, soil clean up levels were developed.

Soil Vapor Extraction (SVE) is the most logical and appropriate treatment for soil. This treatment technology has been used, including the SITES program, and is currently being recommended by USEPA for sites with similar characteristics (see Attachments I & II). Based on discussions with SVE vendors, there are no conditions at the Bluff Road Site which would prevent the effective remediation of the soils if the system is properly designed and operated (see Attachments). SVE will achieve soil cleanup levels required so that the combined remedy will meet or exceed ARARs in the most cost effective fashion.

de maximis

SVE has an added benefit of being in-situ process as opposed to thermal/incineration which would involve considerable excavation and its associated difficulties regarding materials handling and ash handling. These handling problems and residuals management issues have caused significant problems throughout the EPA regions on both PRP and EPA lead remedial activities. Thermal/incineration will also require significant additional land-use and off-site access both for the equipment itself and staging areas for raw soil and subsequent ash storage. This is a particularly critical concern given the proximity of designated wetlands.

As with any technology, appropriate design is necessary to ensure effectiveness. If EPA is not satisfied that SVE will work at the Site, then we recommend that the Record of Decision provide that if remedial design work, including any necessary pilot testing, indicates that SVE is not effective at this Site, an alternative soil treatment technology, such as thermal/incineration will be required. This approach of providing for a possible backup technology if the preferred technology is shown to be ineffective, has been used at several sites by EPA.

The National Contingency Plan mandates that cost effectiveness be evaluated, and that, among technologies achieving comparable levels of protection, the most cost effective remedy is appropriate. SVE meets those requirements. EPA's March 29, 1990 letter, lowering the estimated amount of soil to be remediated does not effect the cost estimates in the FS. Best engineering practice and experience dictate that the "best case", lower range costs are not appropriate for developing engineering cost estimates. A recent study indicates that the remedial activities cost are routinely 50% higher than the estimated values (see Attachment III). It should be noted that with a range of 16,000 to 45,000 cubic yards of soil, a significant overrun would be experienced using thermal/incineration if the 45,000 number is the appropriate number. However, only a small cost increase would ensue if SVE is the chosen remedy under the same circumstances. Hence, SVE complies with the NCP.

We hope this information is of assistance to the agency in making its final remedial technology selections. We do

49   0386

de maximis

Ms. Michelle Glenn
5 April 1990
Page 3 of 3

request that this letter be included in the administrative
record. If you or your staff have any questions, please
contact me at (615) 691-5052.

Best regards,

For Michael A. Miller

Attachment

cc: Lorelei Borland
    Deborah Espy, USEPA Counsel
    Keith Lindler, SCDHEC
    Quentin Pair, DOJ

ATTACHMENT I

EPA INTERNAL MEMO CRITICIZING SOIL FLUSHING: TEXT

SUBJECT: Comments on Remedial Design and Remedial Action Work Plan -- Rose Township -- Demode Road Site
TO: Scott Huling
FROM: Ralph Ludwig
DATE: 11/27/89

In summary, I do not support the implementation of a soil flushing process for the subject site as proposed. I feel that the effectiveness of the proposed soil flushing process will be questionable and that soil vacuum extraction (SVE) would be a much better bet. Comments are as follows;

1. The success of the proposed soil flushing process would depend on the vadose zone material exhibiting a reasonable degree of permeability and homogeneity. The subject report describes the vadose zone as consisting of "granular soil" exhibiting a hydraulic conductivity of approximately 3.0E-3 cm/sec. Although this description may, in general, be correct, boring logs from the June 1987 RI/FS report prepared by E.C. Jordan Co. appear to indicate a potentially significant clay content and possibly high degree of heterogeneity within the vadose zone. Such properties of the vadose zone material are not likely to be conducive to a soil flushing process. Significant heterogeneity within the vadose zone coupled with a significant clay content could result in strong preferential flow paths in some areas and little or negligible flow in other areas (i.e. areas of stagnation). Much of the contamination may reside in the lower permeability areas coinciding with areas of stagnation. In other areas, the VOC's may be associated with capillary-held residuals and may be inaccessible to passing water. Given these concerns regarding the nature of the vadose zone and the VOC distribution within the vadose zone, the proposed soil flushing process is not recommended given the availability of SVE.

2. If the vertical permeability of the vadose zone material is 3.0E-3, then an interstitial velocity or leaching rate of about 30 ft/day could theoretically be expected. This would correspond to the removal of about 30 pore volumes in the vadose zone per day. These numbers are based on a conservatively assumed soil porosity of 0.3. Were the vadose zone material homogeneous, the calculated interstitial velocity would suggest that the rate of liquid flow through the vadose zone would not be expected to be a hindrance to the proposed soil flushing process. Due to the apparently significant heterogeneity within the vadose zone, however, strong preferential flow paths probably exist and for most pores, far fewer than 30 volumes per day are removed.

3. The cleanup levels achievable and the time frame required for cleanup will be governed by several factors other than just the rate of fluid flow. These factors include the natural soil organic content and mineralogy, and the kinetics of contaminant desorption and dissolution characteristic of the soil-contaminant matrix. The natural soil organic content and mineralogy of the vadose zone material will govern the means by which contaminants are bound to soil-constituent surfaces and therefore what forces will be required to effect their dissociation or removal. Contaminant desorption and dissolution rates will depend on the specific soil-water partitioning properties of the contaminants and can be expected to decrease with decreasing soil contaminant concentrations. Bench-scale soil column studies on undisturbed and preferably large soil cores would be required to provide the necessary insight into the expected rates of contaminant removal for the particular vadose zone material in question.

4. The implementation of a soil flushing process as proposed will impart an additional source of contamination to the underlying ground water. This is undesirable and should be discouraged particularly given the availability of cleaner technologies such as SVE.

5. Soil vacuum extraction (SVE) would be a more desirable means of remediating the VOC contaminated soils. SVE would avoid the problem of further contaminating the underlying ground water and would effect cleanup much more rapidly. The anticipated faster cleanup time frame is based on the much more rapid diffusion of contaminants into the aqueous phase (as would occur using a soil flushing process). In addition, the advective flow of air in the SVE process will be considerably greater than the advective flow of water in the soil flushing process. As well as encouraging volatilization, SVE can be expected to also stimulate biodegradation of the vadose zone contaminants by providing a continuous and ample source of oxygen. It should be kept in mind that other organic contaminants not classified as VOCs (e.g. napthalene, pentachlorophenol, and phthalates) are also present in the subject soil and that a soil flushing process using water will almost certainly not effectively remove these compounds. Enhanced biodegradation may be the only effective means of remediation for these contaminants.
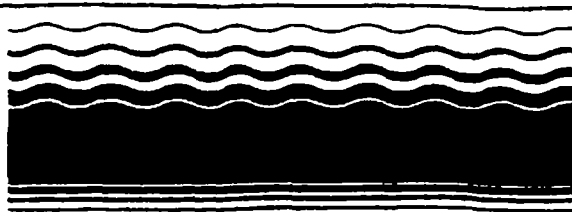
ATTACHMENT II

4 9   0390

♦EPA

SITE

**SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION**

Technology Demonstration Summary

Terra Vac In Situ Vacuum Extraction System Groveland, Massachusetts

Terra Vac Inc's vacuum extraction system was demonstrated at the Valley Manufactured Products Company, Inc., site in Groveland, Massachusetts. The property is part of the Groveland Wells Superfund site and is contaminated mainly by trichloroethylene (TCE). Vacuum extraction entails removal and venting of volatile organic constituents (VOCs) such as TCE from the vadose or unsaturated zone in the ground by use of extraction wells and vacuum pumps. The process of removing VOCs from the vadose zone using vacuum is a patented process.

The eight-week test run produced the following results:

- extraction of 1,300 lb of VOCs

- a steady decline in the VOC recovery rate with time

- a marked reduction in soil VOC concentration in the test area

- an indication that the process can remove VOCs from clay strata

This Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the SITE

program demonstration that is fully documented in two separate reports of the same title (see ordering information at back).

Introduction

Environmental regulations enacted in 1984 (and recent amendments to the Superfund program) discourage the continued use of landfilling of wastes in favor of remedial methods that will treat or destroy the wastes. The Superfund program now requires that, to the maximum extent practicable, cleanups at Superfund sites must employ permanent solutions to the waste problem.

The Superfund Innovative Technology Evaluation (SITE) program is one major response to the challenge of finding safe ways to deal with waste sites. Part of the program includes carefully planned demonstration projects at certain Superfund sites to test new waste treatment technologies. These new alternative technologies will destroy, stabilize, or treat hazardous wastes by changing their chemical, biological, or physical characteristics.

Under the SITE program, which is sponsored jointly by the USEPA Office of Research and Development (ORD) and the Office of Solid Waste and Emergency

response (OSWER), the USEPA selects 10 or 12 Superfund sites each year at which pilot studies of promising technologies can be conducted. Sites are chosen to match the effectiveness and applicability of a particular technology with specific waste types and local conditions. The pilot studies are carefully monitored by the USEPA. Monitoring and data collection determines how effectively the technology treats the waste, how cost-effectively the technology compares with more traditional approaches, and that the operation can be conducted within all public health and environmental guidelines.

The Groveland Wells site was selected for such a demonstration project for 1987. The site is the location of a machine shop, the Valley Manufactured Products Company, Inc., which employs approximately 25 people and manufactures, among other things, parts for valves. The company has been in business at the site since 1964. As an integral part of its building-wide operation of screw machines, the company has used different types of cutting oils and degreasing solvents, mainly trichloroethylene, tetrachloroethylene, trans-1,2-dichloroethylene, and methylene chloride.

The contamination beneath the shop apparently is caused by a leaking storage tank and by former improper practices in the storage and handling of waste oils and solvents. The contamination plume is moving in a northeasterly direction towards and into the Mill Pond.

The USEPA has been involved since 1983, when the Groveland Wells site was finalized on the National Priorities List. The initial Remedial Investigation (RI) of the Valley property was carried out by the responsible party (RP), Valley Manufactured Products Company, Inc. A supplemental RI was conducted by Valley in the fall/winter of 1987 to determine more completely the full nature of contamination at the Valley site. A source control Feasibility Study was performed by USEPA to evaluate various methods for cleaning up or controlling the remaining contaminants. A Record of Decision (ROD) for the site was signed in October 1988 calling for vacuum extraction and groundwater stripping.

The Terra Vac system is being utilized in many locations across the nation. This report is based on monitoring the Terra Vac patented vacuum extraction process (U.S. Patent Nos. 4593760 and 4860639) at the Groveland Wells site during a four-and-one-half-month field operation period, with emphasis on a 56-day

demonstration test active treatment period. The report interprets results of analyses performed on samples and establishes reliable cost and performance data in order to evaluate the technology's applicability to other sites.

The main objectives of this project were:

• The quantification of the contaminants removed by the process.

• The correlation of the recovery rate of contaminants with time.

• The prediction of operating time required before achieving site remediation.

• The effectiveness of the process in removing contamination from different soil strata.

Approach

The objectives of the project were achieved by following a demonstration test plan, which included a sampling and analytical plan. The sampling and analytical plan contained a quality assurance project plan. This QAPP assured that the data collected during the course of this project would be of adequate quality to support the objectives.

The sampling and analytical program for the test was split up into a pretest period, which has been called a pretreatment period, an active period, midtreatment, and a posttreatment period.

The pretreatment period sampling program consisted of:

• soil boring samples taken with split spoons

• soil boring samples taken with Shelby tubes

• soil gas samples taken with punch bar probes

Soil borings taken by split spoon sampling were analyzed for volatile organic compounds (VOCs) using headspace screening techniques, purge and trap, GC/MS procedures, and the EPA-TCLP procedure. Additional properties of the soil were determined by sampling using a Shelby tube, which was pressed hydraulically into the soil by a drill rig to a total depth of 24 feet. These Shelby tube samples were analyzed to determine physical characteristics of the

subsurface stratigraphy such as bulk density, particle density, porosity, pH, grain size, and moisture. These parameters were used to define the basic soil characteristics.

Shallow soil gas concentrations were collected during pre-, mid-, and post-treatment activities. Four shallow vacuum monitoring wells and twelve shallow punch bar tubes were used at sample locations. The punch bar samples were collected from hollow stainless steel probes that had been driven to a depth of 3 to 5 feet. Soil gas was drawn up the punch bar probes with a low-volume personal pump and tygon tubing. Gas-tight 50-ml syringes were used to collect the sample out of the tygon tubing.

The active treatment period consisted of collecting samples of:

• wellhead gas

• separator outlet gas

• primary carbon outlet gas

• secondary carbon outlet gas

• separator drain water

All samples with the exception of the separator drain water were analyzed on site. On-site gas analysis consisted of gas chromatography with a flame ionization detector (FID) or an electron capture detector (ECD). The FID was used generally to quantify the trichloroethylene (TCE) and trans 1,2-dichloroethylene (DCE) values, while the ECD was used to quantify the 1,1,1-trichloroethane (TRI) and the tetrachloroethylene (PCE) values.

The separator drain water was analyzed for VOC content using SW846 8010. Moisture content of the separator inlet gas from the wells was analyzed using EPA Modified Method 4. This method is good for the two-phase flow regime that existed in the gas emanating from the wellhead. See Table 1 for a listing of analytical methods applied.

The posttreatment sampling essentially consisted of repeating pretreatment sampling procedures at locations as close as possible to the pretreatment sampling locations.

The activated carbon canisters were sampled, as close to the center of the canister as possible, and these samples were analyzed for VOC content as a check on the material balance for the process. The method used was P&CAM 127, which consisted of desorption of the carbon with CS_2 and subsequent gas chromatographic analysis.

4 9   0392

Table 1. Analytical Methods

Parameter	Analytical Method	Sample Source
Grain size	ASTM D422-63	Soil borings
pH	SW846* 9040	Soil borings
Moisture (110°C)	ASTM D2216-80	Soil borings
Particle density	ASTM D698-78	Soil borings
Oil and grease	SW846* 9071	Soil borings
EPA-TCLP	F. R. 11/7/86, Vol. 51, No. 216, SW846* 8240	Soil borings
TOC	SW846* 9060	Soil borings
Headspace VOC	SW846* 3810	Soil borings
VOC	GC/FID or ECD	Soil gas
VOC	GC/FID or ECD	Process gas
VOC	SW846* 8010	Separator liquid
VOC	SW846* 8010	Groundwater
VOC	Modified P&CAM 127	Activated carbon
VOC	SW846* 8240	Soil borings

*Third Edition, November 1986.

Process Description

The vacuum extraction process is a technique for the removal and venting of volatile organic constituents (VOCs) from the vadose or unsaturated zone of soils. Once a contaminated area is completely defined, an extraction well or wells, depending upon the extent of contamination, will be installed. A vacuum system induces air flow through the soil, stripping and volatilizing the VOCs from the soil matrix into the air stream. Liquid water is generally extracted as well along with the contamination. The two-phase flow of contaminated air and water flows to a vapor liquid separator where contaminated water is removed. The contaminated air stream then flows through activated carbon canisters arranged in a parallel-series fashion. Primary or main adsorbing canisters are followed by a secondary or backup adsorber in order to ensure that no contamination reaches the atmosphere.

Equipment Layout and Specifications

The equipment layout is shown in Figure 1, and specifications are given in Table 2 for the equipment used in the initial phase of the demonstration. This equipment was later modified when unforeseen circumstances required a shutdown of the system. The vapor-liquid separator, activated carbon canisters, and vacuum pump skid were inside the building, with the stack discharge outside the building. The equipment was in an area of the machine shop where used cutting oils and metal shavings had been stored.

Four extraction wells (EW1 - EW4) and four monitoring wells (MW1 - MW4) were drilled south of the shop. Each well was installed in two sections, one section to just above the clay lens and one section to just below the clay lens. The extraction wells were screened above the clay and below the clay. As shown in Figure 2, the well section below the clay lens was isolated from the section above by a bentonite portland cement grout seal. Each section operated independently of the other. The wells were arranged in a triangular configuration, with three wells on the base of the triangle (EW2, EW3, EW4) and one well at the apex (EW1). The three wells on the base were called barrier wells. Their purpose was to intercept contamination from underneath the building and to the side of the demonstration area, before this contamination reached the main extraction well (EW1). The area enclosed by the four extraction wells defined the area to be cleaned.

Installation of Equipment

Well drilling and equipment setup were begun on December 1, 1987. A mobile drill rig was brought in and equipped with hollow-stem augers, split spoons, and Shelby tubes. The locations of the extraction wells and monitoring wells had been staked out based on contaminant concentration profiles from a previously conducted remedial investigation and from bar punch probe soil gas monitoring.

Each well drilled was sampled at 2-foot intervals with a split spoon pounded into the subsurface by the drill rig in advance of the hollow stem auger. The hollow stem auger would then clear out the soil down to the depth of the split spoon, and the cycle would continue in that manner to a depth of 24 feet. The drilling tailings were shoveled into 55-gallon drums for eventual disposal. After the holes were sampled, the wells were installed using 2-inch PVC pipes screened at various depths depending upon the characteristics of the soil in the particular hole. The deep well was installed first, screened from the bottom to various depths. A layer of sand followed by a layer of bentonite and finally a thick layer of grout were required to seal off the section below the clay lens from the section above the clay lens. The grout was allowed to set overnight before the shallow well pipe was installed at the top of the grout. A layer of sand bentonite and grout finished the installation.

VOC Removal From the Vadose Zone

The permeable vadose zone at the Groveland site is divided into two layers by a horizontal clay lens, which is relatively impermeable. As explained previously, each extraction well had a separate shallow and deep section to enable VOCs to be extracted from that
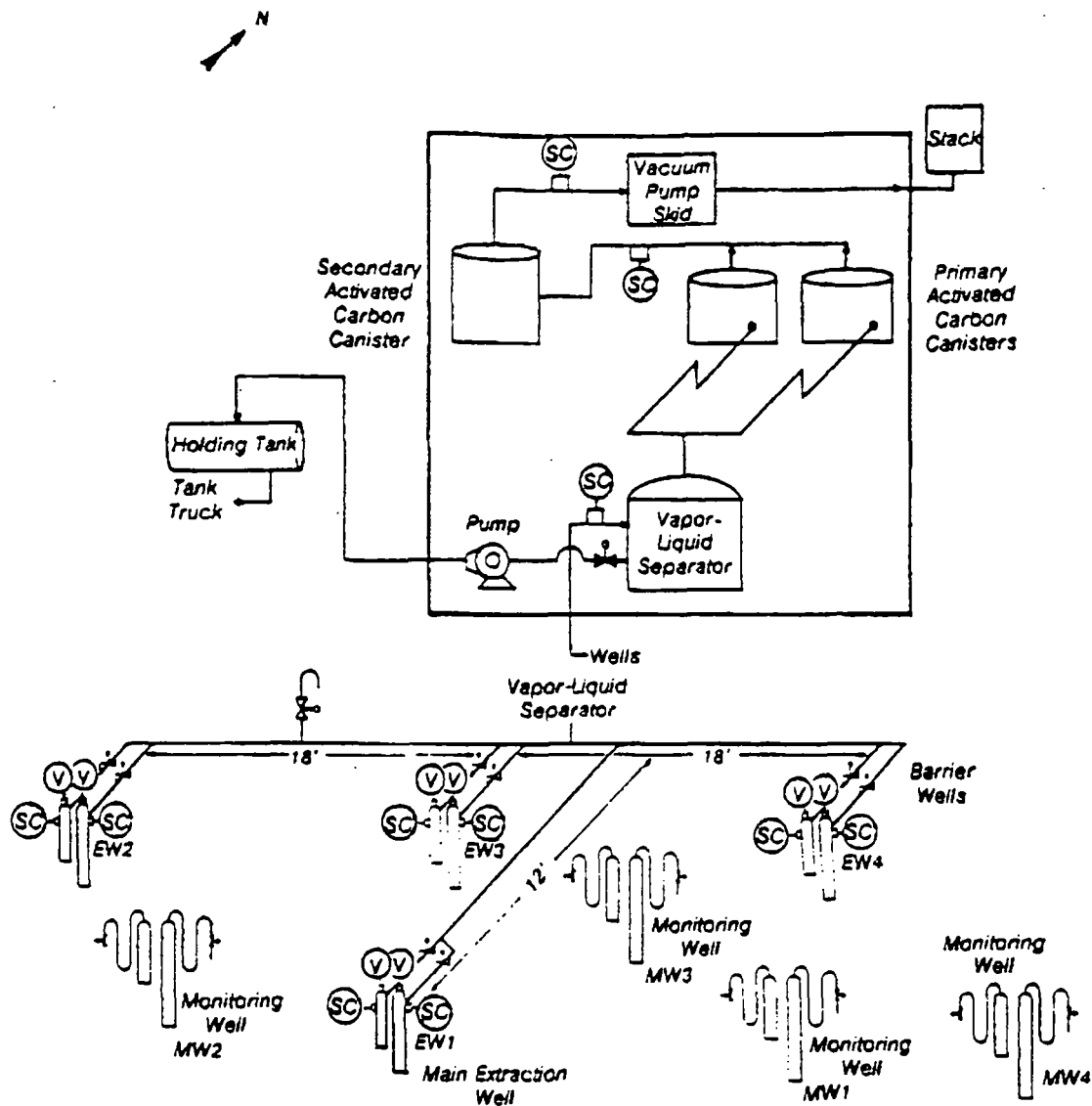
49   0393

Figure 1. Schematic diagram of equipment layout.

Table 2. Equipment List

| Equipment	Number Required	Description
Extraction wells	4 (2 sections each)	2" SCH 40 PVC 24' total depth
Monitoring wells	4 (2 sections each)	2" SCH 40 PVC 24' total depth
Vapor-liquid separator	1	1000-gal capacity, steel
Activated carbon canisters	Primary: 2 units in parallel	Canisters with 1200 lb of carbon in each canister - 304 SS
	Secondary: 1 unit	4" inlet and outlet nozzles
im unit	1	Terra Vac Recovery Unit - Model PR17 (25 HP Motor)
Holding tank	1	2000-gal capacity - steel
Pump	1	1 HP motor - centrifugal

4 9   0394

2" PVC Pipe
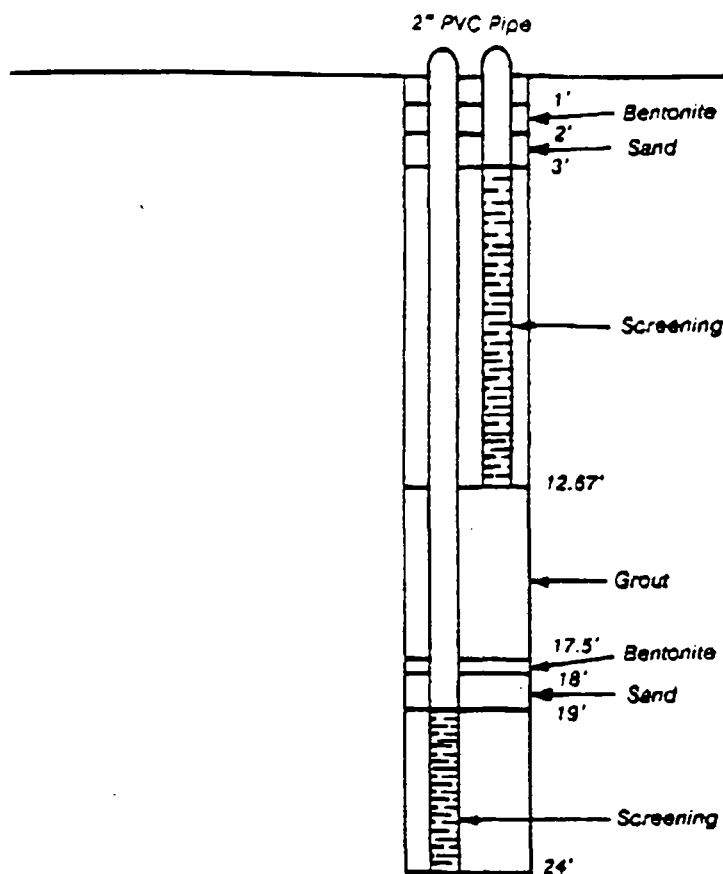
Figure 2. Schematic diagram of an extraction well.

area of the vadose zone above and below the clay lens. The quantification of VOCs removed was achieved by measuring

- gas volumetric flow rate by rotameter and wellhead gas VOC concentration by gas chromatography
- the amount of VOCs adsorbed by the activated carbon canisters by desorption into CS_2 followed by gas chromatography.

VOC flow rates were measured and tabulated for each well section separately. The results of gas sampling by syringe and gas chromatographic analysis indicate a total of 1,297 lb of VOCs were extracted over a 56-day per-●5% of which was trichloroethylene. y good check on this total was ●●●● by the activated carbon VOC analysis, the results of which indicated a VOC recovery of 1353 lb; virtually the same result was obtained by two very different methods.

The soil gas results show a considerable reduction in concentration over the course of the 56-day demonstration period as can be seen from Figures 3 and 4. This is to be expected since soil gas is the vapor halo existing around the contamination and should be relatively easy to remove by vacuum methods.

A more modest reduction can be seen in the results obtained for soil VOC concentrations by GC/MS purge-and-trap analytical techniques. Soil concentrations include not only the vapor halo but also interstitial liquid contamination that is either dissolved in the moisture in the soil or exists as a two-phase liquid with the moisture.

Table 3 shows the reduction of the weighted average TCE levels in the soil during the course of the 56-day demonstration test. The weighted average TCE level was obtained by averaging soil concentrations obtained every two feet by split spoon sampling methods over the entire 24-foot depth of the wells. The largest reduction in soil TCE concentration occurred in extraction

well 4, which had the highest initial level of contamination. Extraction well 1, which was expected to have the greatest concentration reduction potential, exhibited only a minor decrease over the course of the test. Undoubtedly this was because of the greater-than-expected level of contamination that existed in the area around monitoring well 3 that was drawn into the soil around extraction well 1. The decrease in the TCE level around monitoring well 3 tends to bear this out.

Effectiveness of the Technology in Various Soil Types

The soil strata at the Groveland site can be characterized generally as consisting of the following types in order of increasing depth to groundwater:

- medium to very fine silty sands
- stiff and wet clays
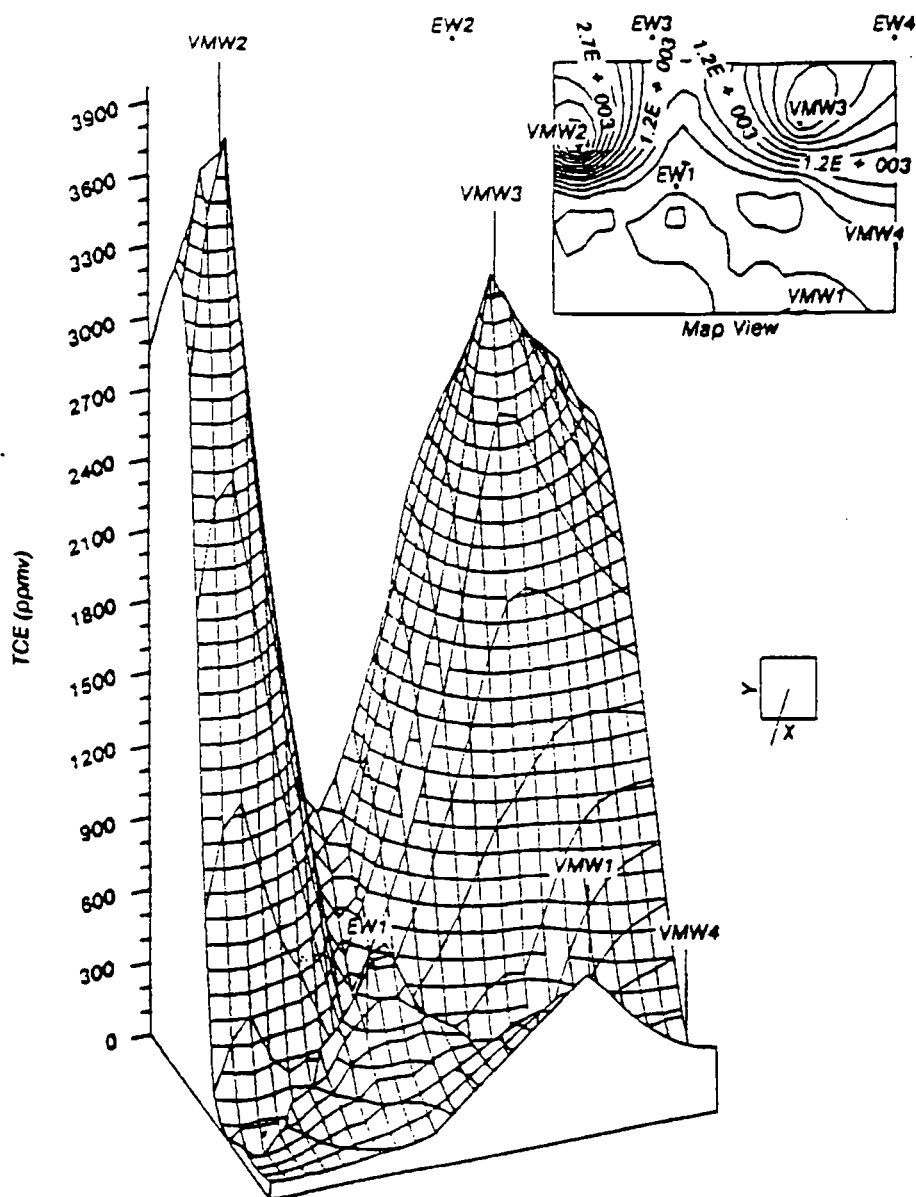- sand and gravel

4 9   0395

Figure 3. Pretreatment shallow soil gas concentration.

Soil porosity, which is the percentage of total soil volume occupied by pores, was relatively the same for both the clays and the sands. Typically porosity, over the 24-foot depth of the wells, would range between 40% and 50%. Permeabilities, or more accurately hydraulic conductivities, ranged from 10^{-4} cm/sec for sands to 10^{-8} cm/sec for the clays corresponding grain sizes equal to 10^{-1} mm to 10^{-3} mm.

Pretest soil boring analyses indicated in general that most of the contamination was in the strata above the clay lens, with a considerable quantity perched on top of the clay lens. This was the case for extraction well 4, which showed an excellent reduction of TCE concentration in the medium to fine sandy soils existing above the clay layer, with no TCE detected in the clay in either the pretest or posttest borings (see Table 4). One of the wells, however, was an exception. This was monitoring well 3, which contained the highest contamination levels of any of the wells, and was exceptional in that most of the contamination was in a wet clay stratum. The levels of contamination were in the 200 to 1600 ppm range before the test. After the test, analyses of the soil boring adjacent to monitoring well 3 showed levels in the range of ND-60 ppm in the same clay stratum. The data suggest that the technology can desorb or otherwise mobilize VOCs out of certain clays (see Table 5).

From the results of this demonstration it appears that the permeability of a soil need not be a consideration in applying the vacuum extraction technology. This may be explained by the fact that the porosities were approximately the same for all soil strata, so that the total flow area for stripping air was the same in all soil strata. It will take a long time for a liquid contaminant to percolate through clay with its small pore size and
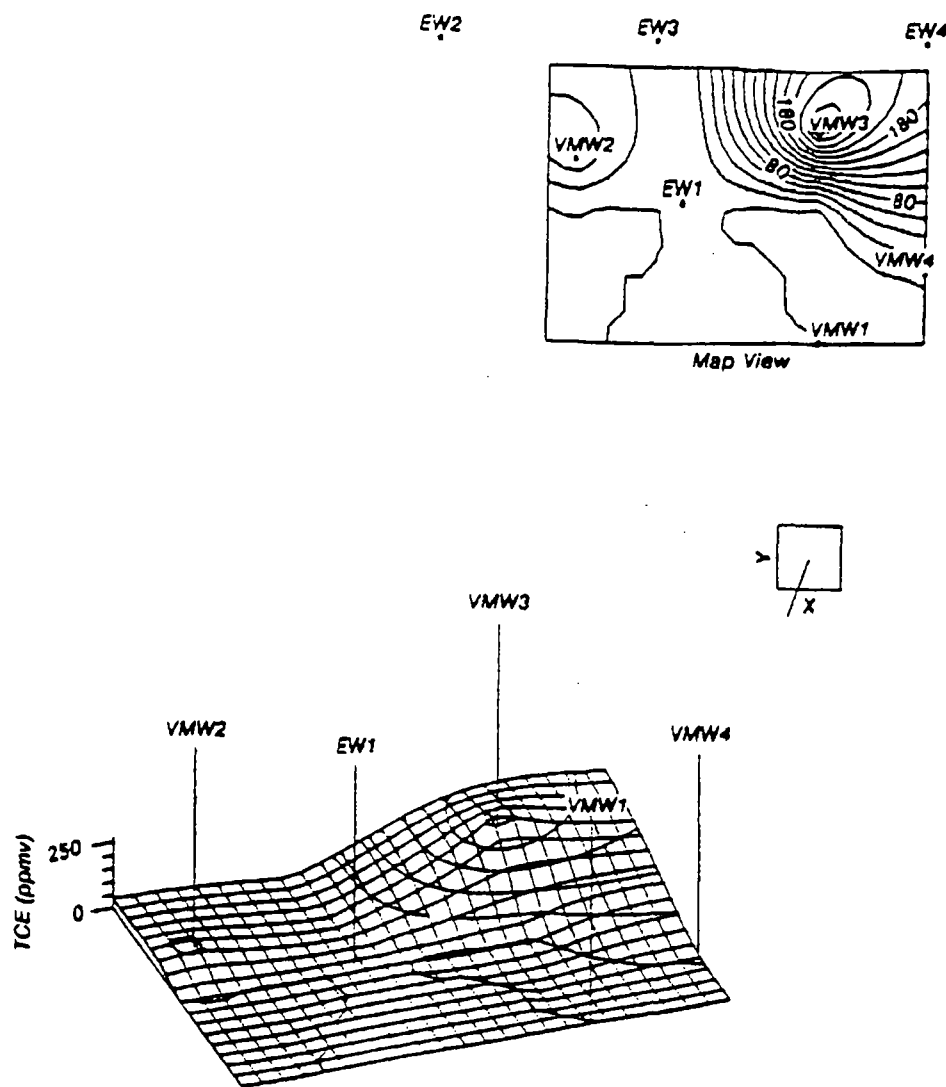
4 9   0396

Map View

Figure 4. Posttreatment shallow soil gas concentration.

consequent low permeability. However, the much smaller air molecules have a lower resistance in passing through the same pores. This may explain why contamination was generally not present in the clay strata but when it was, it was difficult to remove. Further testing be done in order to confirm this ng.

Correlation of Declining VOC Recovery Rates

The vacuum extraction of volatile organic constituents from the soil may be viewed as an unsteady state process taking place in a nonhomogeneous environment acted upon by the combined convective forces of induced stripping air and by the vacuum induced volatilization and diffusion of volatiles from a dissolved or sorbed state. As such it is a very complicated process, even though the equipment required to operate the process is very simple.

Unsteady state diffusion processes in general correlate well by plotting the logarithm of the rate of diffusion versus time. Although the representation of the vacuum extraction process presented here might be somewhat simplistic, the correlation obtained by plotting the logarithm of the concentration of contaminant in the wellhead gas versus time and obtaining a least squares best fit line was reasonably good. This type of plot, shown in Figure 5, represents the data very well and is more valid than both a linear graph or one plotting concentration versus log time, in which a best fit curve would actually predict gas concentrations of zero or less.

4 9   0397

Table 3. *Reduction of Weighted Average TCE Levels in Soil (TCE Conc. in mg/kg)*

Extraction Well	Pretreatment	Posttreatment	% Reduction
1	33.98	29.31	13.74
2	3.38	2.36	30.18
3	6.89	6.30	8.56
4	96.10	4.19	95.64
Monitoring Well			
1	1.10	0.34	69.09
2	14.75	8.98	39.12
3	227.31	84.50	62.83
4	0.87	1.05	--

Table 4. *Extraction Well 4 – TCE Reduction in Soil Strata*

Depth ft	Description of Strata	Permeability cm/sec	TCE Conc. ppm pre	TCE Conc. ppm post
0-2	Med. sand w/gravel	10^{-4}	2.94	ND
2-4	Lt. brown fine sand	10^{-4}	29.90	ND
4-6	Med. stiff lt. brown fine sand	10^{-5}	260.0	39
6-8	Soft dk. brown fine sand	10^{-5}	303.0	9
8-10	Med. stiff brown sand	10^{-4}	351.0	ND
10-12	V stiff lt. brown med. sand	10^{-4}	195.0	ND
12-14	V stiff brown fine sand w/silt	10^{-4}	3.14	2.3
14-16	M stiff grn-brn clay w/silt	10^{-6}	ND	ND
16-18	Soft wet clay	10^{-6}	ND	ND
18-20	Soft wet clay	10^{-6}	ND	ND
20-22	V stiff brn med-coarse sand	10^{-4}	ND	ND
22-24	V stiff brn med-coarse w/gravel	10^{-3}	6.71	ND

Table 5. *Monitoring Well 3 – TCE Reduction in Soil Strata*

| Depth ft	Description of Strata	Permeability cm/sec	TCE Conc. ppm pre	TCE Conc. ppm post
0-2	M. stiff brn. fine sand	10^{-5}	10.30	ND
2-4	M. stiff grey fine sand	10^{-5}	8.33	800
4-6	Soft lt. brn. fine sand	10^{-4}	80.0	84
6-8	Lt. brn. fine sand	10^{-4}	160.0	ND
8-10	Stiff V. fine brn. silty sand	10^{-4}	ND	63
10-12			NR	2.3
12-14	Soft brown silt	10^{-4}	316.0	ND
14-16	Wet green-brown silty clay	10^{-6}	195.0	ND
16-18	Wet green-brown silty clay	10^{-6}	218.0	62
18-20	Wet green-brown silty clay	10^{-6}	1570.0	2.4
20-22	Silt, gravel, and rock frag.	10^{-4}	106.0	ND
22-24	M. stiff lt. brn. med. sand	10^{-4}	64.1	ND

4 9   0398
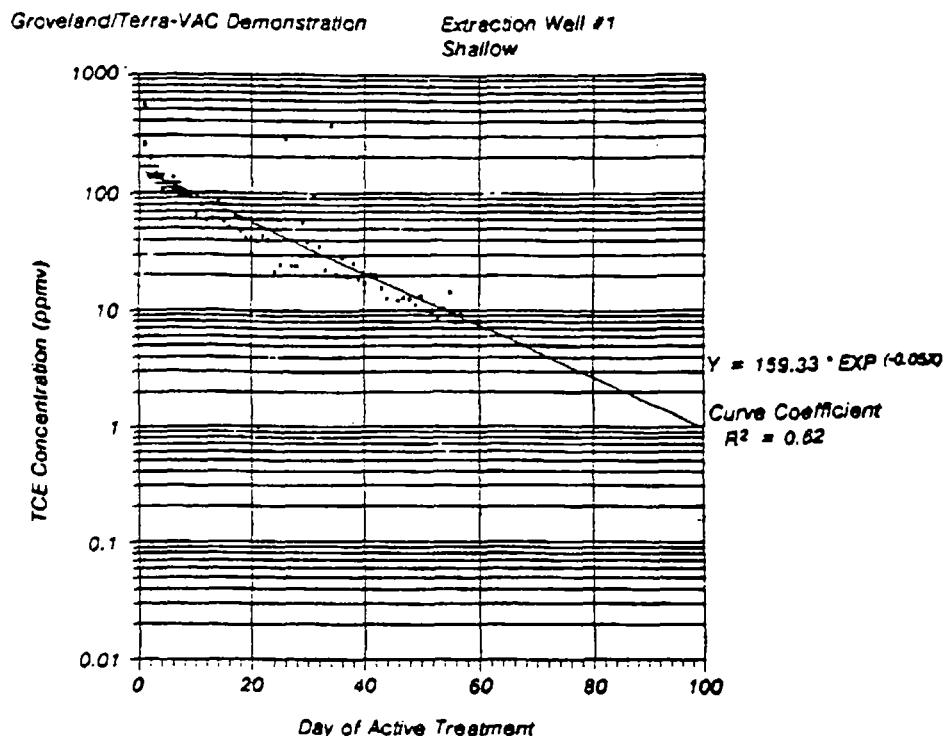
Figure 5. Wellhead TCE concentration vs time.

Looking at the plots for extraction well 1, shallow and deep, equations are given for the least squares best fit line for the data points. If the vacuum extraction process is run long enough to achieve the detection limit for TCE on the ECD, which is 1 ppbv, the length of time required to reach that concentration would be approximately 250 days on the shallow well and approximately 300 days on the deep well.

Prediction of Time Required for Site Remediation

The soil concentration that would be calculated from the wellhead gas concentration using Henry's Law is included in the last column of Table 6. Calculations for the predicted soil concentrations were made assuming a bulk density of the soil of 1761 kg/m³, a total porosity of 50%, and a moisture content of 20%. The calculated air filled porosity of the soil is approximately 15%. Henry's constant was taken to be 0.492 KPa/m³-gmol at 40°F.

Table 6. Comparison of Wellhead Gas VOC Concentration and Soil VOC Concentration

Extraction Well	TCE Concentration in Wellhead Gas ppmv	TCE Concentration in Soil ppmw	Predicted by Henry's Law ppmw
1S	9.7	54.5	0.11
1D	5.6	7.2	0.07
2S	16.4	ND	0.20
2D	14.4	20.4	0.17
3S	125.0	20.9	1.53
3D	58.7	18.0	0.74
4S	1095.6	9.1	12.49

4 9   0399

Given the nonhomogeneous nature of the subsurface contamination and interactions of TCE with organic matter in the soil, it was not possible to obtain a good correlation between VOC concentrations in wellhead gas and soil in order to predict site remediation times. Henry's Law constants were used to calculate soil concentrations from wellhead gas concentrations and the calculated values obtained, correcting for air filled porosity, were lower than actual soil concentrations by at least an order of magnitude (see Table 6).

Before one can attempt to make a rough estimation of the remediation time, a target value for the particular contaminant in the remediated soil must be calculated. This target concentration is calculated by using two mathematical models, the Vertical and Horizontal Spread Model (VHS) and the Organic Leachate Model (OLM) (EPA Draft Guidelines for Petitioning Waste Generated by the Petroleum Refinery Industry, June 12, 1987). The mathematical models allow the use of a regulatory standard for ‌king water in order to arrive at a ‌t soil concentration.

‌he VHS model is expressed as the following equation:

$$C_y = C_0 \, erf \, (Z/(2(a_z Y)^{0.5})) \, erf \, (X/(a_t Y)^{0.5})$$

where:

C_y = concentration of VOC at compliance point (mg/l)

C_0 = concentration of VOC in leachate (mg/l)

erf = error function (dimensionless)

Z = penetration depth of leachate into the aquifer

Y = distance from site to compliance point (m)

X = length of site measured perpendicular to the direction of groundwater flow (m)

a_t = lateral transverse dispersivity (m)

a_z = vertical dispersivity (m)

A simplified version of the VHS model is most often used, which reduces the above equation to:

$$C_y = C_0 C_f$$

where:

C_f = erf $(Z/(2(a_z Y)^{0.5}))$ erf $(X/(a_t Y)^{0.5})$, which is reduced to a conversion factor corresponding to the amount of contaminated soil

The Organic Leachate Model (OLM) is written as:

$$C_0 = 0.00211 \, C_s^{0.678} S^{0.373}$$

where:

C_0 = concentration of VOC in leachate (mg/l)

C_s = concentration of VOC in soil (mg/l)

S = solubility of VOC in water (mg/l)

The regulatory standard for TCE in drinking water is 3.2 ppb. This regulatory limit is used in the VHS model as the compliance point concentration in order to solve for a value of the leachate concentration. This value of leachate concentration is then used in the OLM model to solve for the target soil concentration.

Once the target soil concentration is determined, a rough estimation of the remediation time can be made by taking the ratio of soil concentration to wellhead gas concentration and extrapolating in order to arrive at a wellhead gas concentration at the target soil concentration. The calculated target soil concentration for this site is 500 ppbw. This corresponds to an approximate wellhead gas concentration of 89 ppb for EW1S. The equation correlating wellhead gas concentration with time (see Figure 5) is then solved to give 150 days running time.

After 150 days the vacuum extraction system can be run intermittently to see if significant increases in gas concentrations occur upon restarting, after at least a two-day stoppage. If there are no appreciable increases in gas concentration, the soil has reached its residual equilibrium contaminant concentration and the system may be stopped and soil borings taken and analyzed.

4 9   0400

The EPA Project Manager. **Mary** Stinson, is with the Risk Reduction Engineering
Laboratory. Edison, NJ 08837 (see below).
The complete report consists of two volumes entitled "Technology Evaluation
Report: SITE Program Demonstration Test. Terra Vac In Situ Vacuum
Extraction System, Groveland. Massachusetts:"
"Volume I" (Order No. PB 89-192 025/AS; Cost $21.95, subject to change)
    discusses the results of the SITE demonstration
"Volume II" (Order No. PB 89-192 033/AS; Cost $36.95, subject to change)
    contains the technical operating data logs. the sampling and analytical   data.
    and the quality assurance data
Both volumes of this report will be available only from:
        National Technical Information Service
        5285 Port Royal Road
        Springfield. VA 22161
        Telephone: 703-487-4650
A related report. entitled "Application Analysis Report: Terra Vac In Situ Vacuum
Extraction System." which discusses the applications and costs, is under
development.
The EPA Project Manager can be contacted at:
        Risk Reduction Engineering Laboratory
        U.S. Environmental Protection Agency
        Edison, NJ 08837

United States   Center for Environmental Research   BULK RATE
Environmental Protection   Information   POSTAGE & FEES PAID
Agency   Cincinnati OH 45268   EPA
                                                                                   PERMIT No. G-35

Official Business
Penalty for Private Use $300

540/S5-89/003

TCPIC- Soil Vapor

EPA SITE Demonstration of the Terra Vac In Situ Vacuum Extraction Process in Groveland, Massachusetts

Mary K. Stinson
Releases Control Branch
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
Edison, New Jersey

This paper presents an EPA evaluation of the patented Terra Vac, Inc.'s in situ vacuum extraction process that was field-demonstrated on a trichloroethylene (TCE) contaminated soil in Groveland, Massachusetts, under the EPA Superfund Innovative Technology Evaluation (SITE) program. The Terra Vac process employs vacuum for removal and venting of volatile organic compounds (VOCs), such as TCE, from the subsurface soil without excavation. Results of the eight-week continuous operation of the Terra Vac process in the field are as follows:

- high VOC extraction rates, achieving in eight weeks a total extraction of 1,300 lb of VOCs;

- an indication that this technology can achieve site remediation to the desired levels of VOC concentration in the soil;

- an indication that the process is effective in removing VOCs from soils of low permeability, such as clays, if soil has sufficient air-filled porosity;

- a correlatable decline in the VOC recovery rate with time that can be used to estimate operating time needed for site remediation;

- very reliable operation of the system in all weather conditions (test was performed in the winter);

- process is economical with estimated costs per ton of treated soil between $10 to $150.

The demonstration site was a property of an operating machine shop in Groveland, Massachusetts. The site was contaminated with VOCs, mainly trichloroethylene, which had been used as a degreasing solvent. The Terra Vac system was designed, installed, and operated by Terra Vac, Inc. Evaluation of the process was performed by EPA based on the results from an extensive sampling and analytical program and on daily observation of the operations.

The contamination of the Valley property was caused by a leaking storage tank and by former improper storage and handling of waste oils and solvents. The total amount of contamination at the Valley site has been estimated at between 3,000 and 30,000 lb of volatile organic compounds. The contamination is located in soil underneath and around the machine shop building.

The subsurface profile of the 25-ft vadose zone at the site consists of different soil types with increasing depth:

- medium to very fine silty sands from the surface to a depth of about 12 ft;

- a stiff and wet clay layer from 3 to 7 ft in depth;

- coarse sand and gravel below the clay layer.

Most of the subsurface contamination is above the clay layer with the highest concentration adjacent to it. Also, a considerable amount of water is perched on the clay layer, which would be extracted by the vacuum system. The depth to the groundwater varies seasonally from 27 to 52 feet. The groundwater table follows a bedrock surface sloping towards a water reservoir called Mill Pond located about 400 ft northeast of the northern edge of the machine shop. Mill Pond is a source of Groveland's drinking water supply. Two of Groveland's municipal wells have been contaminated with VOCs and are presently treated with activated carbon.

The Groveland Wells site was finalized on the National Priorities List in 1983. Remedial Investigations (RI) studies were performed by the Valley Manufactured Products Company, Inc. under the supervision of EPA Region 1. A Record of Decision (ROD) for the site was signed in October 1988 with recommendations of vacuum extraction and groundwater stripping for the site remediation. The SITE field demonstration of the Terra Vac pro-

The field demonstration of the Terra Vac in situ vacuum extraction process was conducted at the Valley Manufactured Products Company, Inc. property, which is a part of the Groveland Wells Superfund site, in Groveland, Massachusetts. Trichloroethylene (TCE) is the main contaminant of the soil at this property.

The Valley Manufactured Products Company, Inc., has been operating a small machine shop since 1964. It employs approximately 25 people and manufactures small metal parts, such as valves and screws. In the manufacturing process, the company uses cutting oils and degreasing solvents. In the past, such solvents as trichloroethylene, tetrachloroethylene, trans-1,2-dichloroethylene, and methylene chloride were used. Presently, the company uses biodegradable solvents. Groveland, Massachusetts is a pleasant, small, rural town. The Valley shop is located in a residential area of Groveland.

Table I.   Compounds successfully removed by the Terra Vac Process.

Volatiles	Semivolatiles	Hydrocarbons
benzene	chlorobenzene	gasoline
toluene	dichlorobenzene	jet fuel
xylenes	trichloropropane	Stoddard solvent
ethylbenzene		diesel
hexane		kerosene
chloroform		heavy naphthas
methylene chloride		
tetrachloroethylene		
trichloroethylene		
dichloroethylene		
ethyl cyclohexane		
methyl ethyl ketone		
methyl isobutyl ketone		
methanol		
acetone		
pyridine		
tetrahydrofuran		
dimethylfuran		
carbon tetrachloride		
trichloroethane		

cess took place from November 1987 to May 1988 and, thus, influenced the selection of treatment technologies for the ROD. In situ vacuum extraction is particularly attractive for remediation of the Valley soil. This is because the machine shop can continue its operation while the cleanup takes place.

Terra Vac Process Description

The Terra Vac process or the vacuum extraction technology it uses was developed over five years ago. To date, the process has been used to clean up soil and groundwater contaminated with volatile and semivolatile organic compounds at more than 60 waste sites in the United States. The Terra Vac process is protected by two patents that relate directly to vacuum extraction and to removal of volatile organic compounds from the vadose zone using vacuum (U.S. Patent Nos. 4,593,760 and 4,660,639). The vadose zone is defined as the subsurface soil zone located between the surface soil and groundwater.

Vacuum extraction is typically implemented in situ for treatment of the vadose zone of soil. Such was the Terra Vac process application in its demonstration in Groveland. However, Terra Vac claims and implements several other applications of vacuum extraction. Groundwater can be removed simultaneously from vacuum extraction wells while soil venting takes place. Vacuum extraction can be used to remove liquid-phase hydrocarbons floating on the water table. Furthermore, this process also can be used ex situ to treat excavated soil.

To apply the process to in situ treatment of soil, extraction wells are installed in the contaminated vadose soil. Vacuum wells are designed with a vac-

uum-tight seal near the surface and an extraction zone (screen) corresponding to the profile of subsurface contamination. The extraction wells are connected through a manifold system to a vacuum line that leads through a liquid/water separator and a vapor treatment system to a vacuum pump.

A vacuum pump or blower induces air flow through the soil, stripping and volatilizing the VOCs from the soil matrix into the air stream. Liquid water, if present in soil, is also extracted along with the contamination. The two-phase stream of contaminated air and water flows to a vapor/liquid separator where contaminated water is removed. The contaminated air stream then flows through a treatment system such as gas-phase activated carbon to remove contaminants from the air stream. The clean air is exhausted to the atmosphere through a vent.

Successful design and operation of the vacuum extraction system must consider site conditions, soil properties, and chemical properties of the contaminant. Depending on the depth to groundwater and the soil type, the radius of influence of an extraction well can range from tens to hundreds of feet. The soil should have a sufficient air-filled porosity to allow for in situ stripping of the VOCs from the soil matrix. The contaminant should have a Henry's constant of 0.001 or higher to be removed effectively in a vacuum extraction system. Henry's constant, which is determined for a given compound from the relationship according to Henry's Law, is a measure of a degree of this compound's volatility. Henry's Law governs partitioning of a compound between its amount dissolved in a liquid and its amount as vapor above that liquid. Though Henry's Law applies only to ideal solutions,

knowledge of the theoretical value of Henry's constant for a particular contaminant is useful when considering its removal with vacuum extraction. Terra Vac gives a list of compounds for which the process has been successful. This is shown in Table I.

Terra Vac uses vapor flow models that are calibrated to site conditions to determine design parameters and sensitivity before pilot testing or full-scale cleanup is implemented. Terra Vac often conducts pilot-scale testing prior to the design of a full-scale remediation of a large site.

Field Demonstration of the Terra Vac Process

Demonstration of the Terra Vac process was conducted according to a written plan that was mutually agreed upon by Terra Vac, Inc. and EPA. The objective of this plan was to operate the process long enough to achieve significant reduction in soil VOCs concentration and to establish correlations and relationships that are important to this process.

Terra Vac designed, installed, and operated the vacuum extraction system. Terra Vac equipped the system with sampling ports and recorded measurements of the operating parameters. As part of the design, the system was placed at the periphery of the contaminated area so that significant soil cleanup could be achieved during the course of the project. Eight weeks of continuous operation was deemed adequate for the demonstration test.

EPA performed the sampling and analytical program supported with appropriate Quality Assurance/Quality Control (QA/QC). In addition, EPA assisted the field project with site preparation, Health and Safety programs, and with treatment and disposal of both liquid and gaseous effluent streams.

Terra Vac System at Groveland

The Terra Vac system was installed at the Valley property, south of the machine shop. This location was purposely chosen because it was on the periphery of the contaminated area. The equipment layout is shown in Figure 1. The vacuum manifold was installed outside of the building. Space limitations and maintenance considerations dictated that the rest of the equipment be located inside the building.

Four extraction wells (EW1–EW4) and four monitoring wells (MW1–MW4) were installed to the depth of 24 ft, which is the depth of the vadose zone at the site. Each extraction and monitoring well consisted of two nested, riser pipe sections, one extended
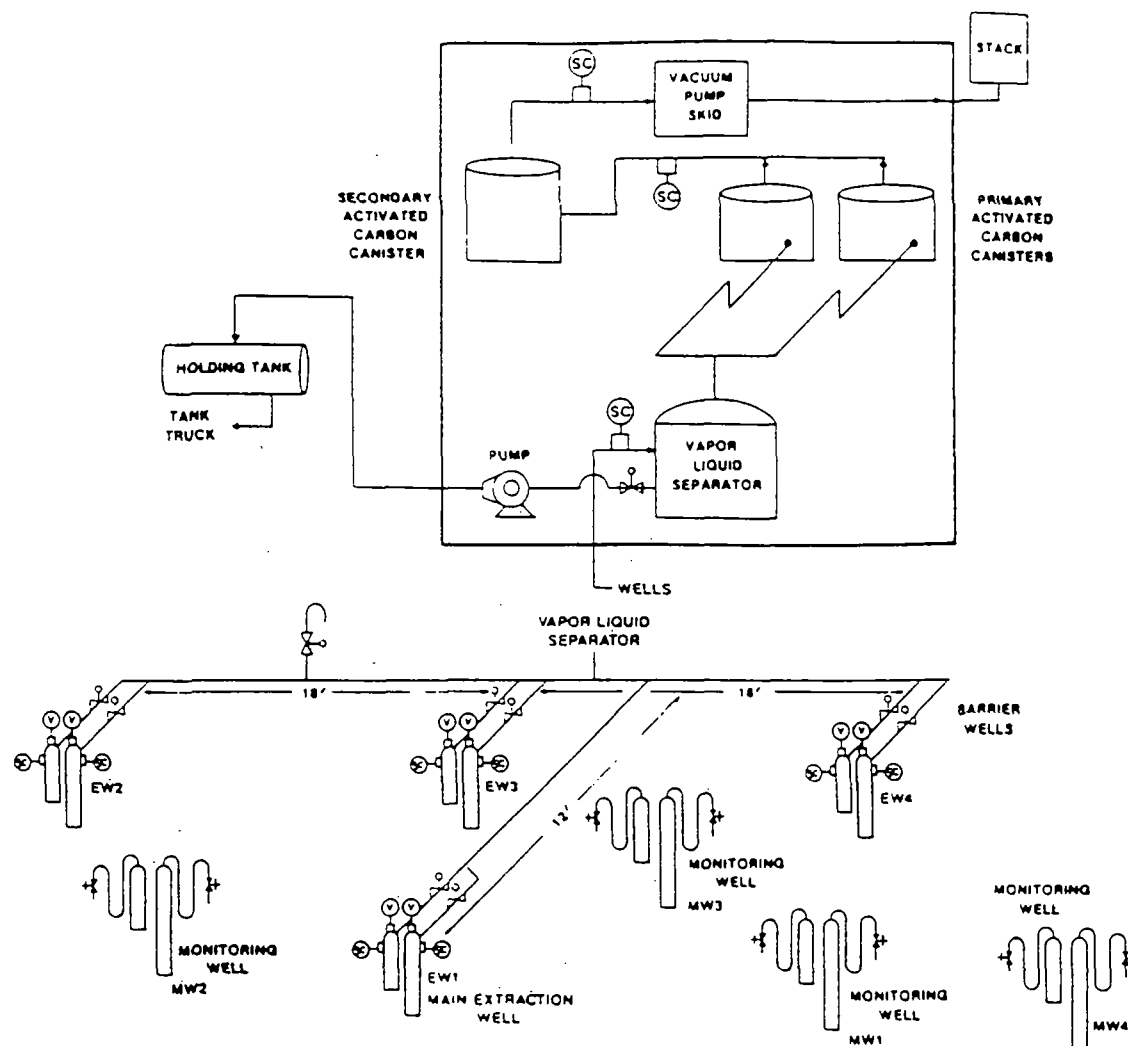
Figure 1.   Schematic diagram of equipment layout.

from the surface to just above the clay layer (a shallow well), and the other to just below the clay layer (a deep well). The shallow wells were screened above the clay and the deep wells were screened below the clay. A schematic diagram of an extraction well constructed of 2-inch PVC pipe is shown in Figure 2. Each of the two well sections was isolated from the other by a bentonite portland cement grout seal and each well section operated independently.

The extraction wells were arranged in a triangular configuration, with one well at the apex of the triangle (EW1) and with three wells on the base of the triangle (EW2, EW3, EW4). The area enclosed by the four extraction wells defined the area of soil on which the fectiveness of the process was to be aluated. The one well at the apex (EW1) was called the main extraction well. The three wells at the base were called barrier wells with the purpose of

intercepting contamination before it could reach the main extraction well (EW1). The four monitoring wells (MW1–MW4) were located at varying distances with respect to the main extraction well (EW1).

The extraction wells were connected through a 4-inch manifold to the rest of the equipment, which was located inside the building. The remaining equipment listed in the sequence of vapor travel in the vacuum line was a 1,000-gal vapor/liquid separator, two 1,000-lb canisters of a dry-phase activated carbon, a 1,000-lb canister of a backup activated carbon, a vacuum pump skid which housed a 25-HP blower, and a vent to exhaust the clean air outside of the building. One additional piece of equipment was a 2,000-gal holding tank to which water was intermittently pumped from the vapor/liquid separator.

The system started continuous operation two months after it was installed.

Part of the delay was because of a mutually agreed work stoppage for about two weeks right after the system was installed (Christmas Holidays). After a few days of system startup in early January, it was necessary to stop it for modifications. This was because the equipment was not sized properly for the much higher-than-expected recovery rates for VOCs and water. The original design of the system was done from the available data on the site and not from preliminary field studies, such as a pilot test.

Thus, a 1,000-gal water/vapor separator with a supporting 2,000-gal water holding tank was installed to replace the initial 200-gal water/vapor separator without any holding tank. Three 1,000-lb activated carbon canisters replaced the eight 200-lb activated carbon canisters. Also, the manifold was insulated and heat-traced to prevent freezing of water that would block the vacuum line.

All these modifications were done quickly, but because of the waiting time for arrival of the new equipment and the new activated carbon, the modified system was started on February 11, 1988, for its eight-week continuous run. The system was stopped for a few days after its four-week run for soil sampling. Other brief stoppages of the system were only for exchanging spent activated carbon.

The only operational difficulty encountered during the period of continuous operation was silting-out of one of the extraction wells. A deep well, EW4, was silted out after four weeks of operation and became nonfunctional. The best remedy for this might be installation of a new well nearby, which was not necessary for this project.

Sampling and Analytical Program

The sampling and analytical program consisted of four periods:

- pre-test sampling (before startup of the vacuum extraction);
- mid-test sampling (after a four-week operation);
- active period sampling (during operation of vacuum extraction);
- post-test sampling (vacuum extraction stopped after an eight-week operation).

The pre-test, mid-test, and post test sampling program consisted of:

- soil boring samples taken with split spoons;
- soil boring samples taken with Shelby tubes;
- soil gas samples taken with punch bar probes.

VOCs present as contaminants of the site soil were the following compounds:

- trichloroethylene (TCE);
- perchloroethylene (tetrachloroethylene) (PCE);
- 1,1,1-trichloromethane (methyl chloroform) (TRI);
- trans-1,2-dichloroethylene (DCE).

Gas analyses, including wellhead gas and soil gas were done on site with gas chromatography. All other analyses were done off site.

Soil borings taken every 2 ft with split spoons to the depth of 24 ft were analyzed for volatile organic compounds using headspace screening techniques, purge and trap methods, and by gas chromatography and mass spectrometry (GC/MS) procedures.

Soil borings taken every 2 ft with Shelby tubes to the depth of 24 ft (undisturbed soil) were analyzed for physical soil properties such as density, permeability, grain size, and moisture. Samples with Shelby tubes were col-

lected only during the pre-test and post-test periods.

Shallow gas samples were taken with punch bar probes at the depth of 3 to 5 ft by using a personal pump, Tygon tubing, and a gas-tight syringe. These samples were analyzed with a gas chromatograph.

The active period sampling program consisted of taking samples from sampling ports at the following locations:

- wellhead gas (from all extraction and monitoring wells);
- water/vapor separator outlet gas;
- primary carbon outlet gas;
- secondary carbon outlet gas;
- vacuum pump outlet gas;
- water/vapor separator drain water.

All gas samples were taken with a 50 mL gas-tight syringe and were analyzed by one of two gas chromatographs, one with a flame ionization detector (FID) and the other with an electron capture detector (ECD), respectively. Choice of a detector depended on the level of a compound concentration in the sample. In this program, the FID was used to quantify the trichloroethylene (TCE) and the trans 1,2-dichloroethylene (DCE), while the ECD was used to quantify the 1,1,1-trichloromethane (TRI) and the tetrachloroethylene (PCE).

The activated carbon canisters were sampled close to the center of the canister and samples were analyzed for VOC content by desorption of the carbon with carbon disulfide and subsequent gas chromatographic analysis.

Analytical methods used are listed in Table II.

Other Field Measurements

Terra Vac was responsible for the operation and accuracy of all temperature, pressure, and flowrate measure-

ment equipment. However, the operational data were recorded by EPA. Flow measurements were made with a portable rotameter. Vacuum on extraction wells was measured with vacuum gauges and on monitoring wells with manometers. Temperature was measured with dial thermometers. Moisture content of the separator inlet gas from the extraction wells was measured by the EPA Modified Method 4.

Results of the Eight-week Demonstration of the Terra Vac System in Groveland

Evaluation of the results proved the capability of the Terra Vac technology to remediate a site contaminated with volatile organic compounds. Though a full remediation of this site with this technology may take a year or longer, a significant reduction in VOC concen-

Table II. Analytical methods.

Parameter	Analytical method	Sample source
Grain size	ASTM D422-63	Soil borings
pH	SW846* 9040	Soil borings
Moisture (110°C)	ASTM D2216-80	Soil borings
Particle density	ASTM D698-78	Soil borings
Oil and grease	SW846* 9071	Soil borings
EPA-TCLP	F.R. 11/7/86, Vol. 51, No. 216, SW846* 8240	Soil borings
TOC	SW846* 9060	Soil borings
Headspace VOC	SW846* 3810	Soil borings
VOC	GC/FID or ECD	Soil gas
VOC	GC/FID or ECD	Process gas
VOC	SW846* 8010	Separator liquid
VOC	SW846* 8010	Groundwater
VOC	Modified P&CAM 127	Activated carbon
VOC	SW846* 8240	Soil borings

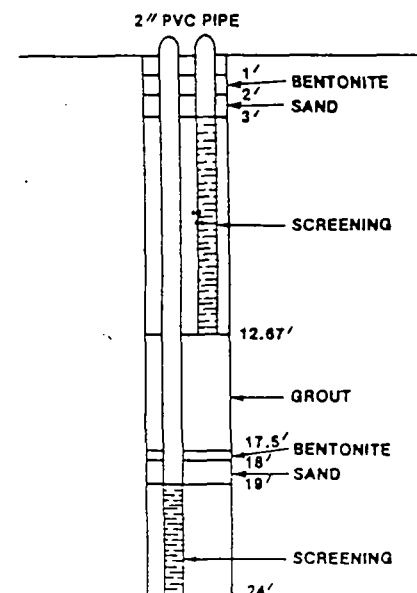* *Test Methods for Evaluating Solid Waste*, 3rd ed., Nov. 1986.

Figure 2. Schematic diagram of an extraction well.

tration in the test area has been achieved in eight weeks. Specific results are grouped under two headings: direct results and correlative results.

Direct Results of the Demonstration

Quantification of VOCs Removed

Quantification of VOCs removed in eight weeks from the tested area was done with the use of two different methods. The first method involved analysis of wellhead gas concentration with gas chromatography and measurement of gas volumetric flowrate with a rotameter. The total amount of recovered VOCs with this method was 1,297 lb of which 95 percent was trichloroethylene. The second method determined the amount of VOCs adsorbed on the activated carbon by desorption into carbon disulfide followed by gas chromatography. The results of activated carbon VOC analysis showed a total VOC recovery of 1353 lb. Thus, a good agreement was achieved on the amount of recovered VOCs with two independent methods.

Reduction of VOC Concentration in Soil Gas

The soil gas results show a 95 percent reduction in VOC concentration in the tested area, which proves the ease of removing the VOCs from soil by vacuum extraction. This reduction is illustrated by three-dimensional shallow soil gas plots for both the pre-test (Figure 3) and the post-test (Figure 4) soil gas concentrations, respectively. In these plots, the location of the main extraction well (EW1) is the origin (0.0) of the x, y, and z coordinate system. All locations from which the soil gas samples were taken are defined with the x and y coordinates. The TCE concentrations of all samples are plotted on the z coordinate. The continuity of these plots by filling in speculated TCE values among the real data points was done with the use of a Kriging technique. Kriging is the least squares prediction of spatial processes, such as trend surface analysis, and was used here to picture the spatial distribution of TCE concentrations in soil gas.

The real data points came from the analyses of shallow soil gas samples taken from 16 locations with respect to the main extraction well.

Reduction of VOC Concentration in Soil

An examination of the data presented in Tables III, IV and V shows some inconsistencies with regard to pre-test and post-test soil concentrations. This can be expected when it is recognized
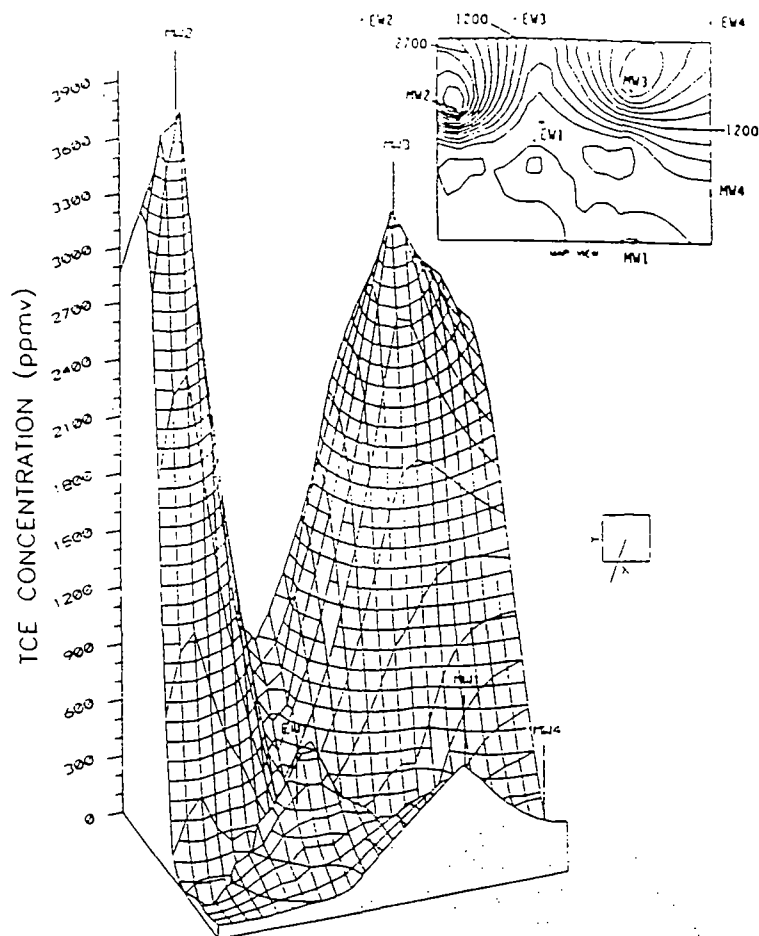

Figure 3. Pre-treatment shallow soil gas concentration.

that the process of vacuum extraction in soil is acting upon a nonhomogeneously contaminated matrix and that it is impossible to sample the same soil twice. However, these inconsistencies do not overshadow the downward trend of contaminant concentration in soil as a result of the vacuum extraction process. Each of the three tables discussed below clearly shows this downward trend in contaminant concentrations.

Table III shows the reduction of weighted average TCE levels in the soil that was achieved in eight weeks. The weighted average TCE level was obtained by averaging soil concentrations collected every 2 ft over the entire 24-ft depth of the wells. The largest reduction (95.6 percent) in soil TCE concentration occurred in the vicinity of the extraction well number 4 (EW4), which had the highest initial level of contamination. Table IV shows TCE concentration reduction in soil strata in the vicinity of EW4. Most of the analyses done on the post-test samples show non-detectable levels of TCE.

The vicinity of the main extraction well (EW1) achieved only a minor reduction in the VOC concentration of about 14 percent. According to the pro-

Table III. Reduction of weighted average TCE levels in soil (TCE concentration in mg/Kg or ppm).

Well	Pre-test	Post-test	% Reduction
EW1	33.98	29.31	13.74
EW2	3.38	2.36	30.18
EW3	6.89	6.30	8.56
EW4	96.10	4.19	95.64
MW1	1.10	0.34	69.09
MW2	14.75	8.98	39.12
MW3	227.31	84.50	62.83
MW4	0.87	1.05	—

EW = extraction well; MW = monitoring well.

Table IV.   Extraction well number 4 (EW4) TCE reduction in soil strata.

Depth ft.	Description of strata	Permeability cm/s	TCE concentration mg/Kg (ppm)	
			Pre-test	Post-test
0–2	Med. sand w/gravel	10^{-4}	2.94	ND
2–4	Lt. brown fine sand	10^{-4}	29.90	ND
4–6	Med. stiff lt. brown fine sand	10^{-5}	260.0	39.0
6–8	Soft. dk. brown fine sand	10^{-5}	303.0	9.0
8–10	Med. stiff brown sand	10^{-4}	351.0	ND
10–12	V. stiff lt. brown med. sand	10^{-4}	195.0	ND
12–14	V. stiff brown fine sand w/silt	10^{-5}	3.14	2.3
14–16	M. stiff grn-brn clay w/silt	10^{-8}	ND	ND
16–18	Soft wet clay	10^{-8}	ND	ND
18–20	Soft wet clay	10^{-8}	ND	ND
20–22	V. stiff brn med-coarse sand	10^{-4}	ND	ND
22–24	V. stiff brn med-coarse sand w/gravel	10^{-3}	6.71	ND

cess design, EW1 was expected to achieve the greatest concentration reduction over the course of the project. This did not occur because of the higher-than-expected level of contamination that existed in the area around the monitoring well number 3.

It was expected that significant reduction in VOC concentration in soil would be achieved in some locations of the tested area but not throughout the entire test area. There were reasons to expect this. One reason was that the eight-week test was relatively short for this technology, which can require an operating time of up to two years to remediate a site such as this one.

The second reason was that this particular arrangement of the four extraction wells enclosing the test area was able to minimize but not prevent migration of contaminants from the adjacent areas. Also, there was a highly contaminated portion of soil in the vicinity of monitoring well number 3 (MW3), which was within the test area and halfway between the main extraction well (EW1) and the three barrier wells (EW2, EW3, EW4). Contamination drawn from the vicinity of MW3 by the main extraction well (EW1), hindered the reduction in VOC concentration in the vicinity of EW1.

Reduction of VOC Concentration in Clay Strata

Table V shows an impressive reduction in VOC concentration in the clay strata in the vicinity of monitoring well number 3 (MW3), where the pre-test samples had TCE concentration levels from 200–1600 ppm and the post-test samples had TCE concentration levels from non-detectable to 60 parts per million. The clay stratum discussed here is the 6-ft layer between 14 and 20 ft below grade.

The pre-test concentration of TCE near MW3 was the highest contamination level measured in the site soil. In addition, this high contamination was contained in the clay layer, while the locations of all other wells showed non-detectable levels of TCE in the clay layer. At the other locations, the contamination was mostly contained in the sandy soil above the clay layer. Thus, the data suggest that vacuum extraction can remove VOCs out of certain clays.

Further, it appears that the air-filled porosity of soil and not the permeability is a limiting factor in applying vacuum extraction. Permeability of the cleaned clay layer was 10^{-8} cm/s while permeability of all soil at the test area ranged from 10^{-3} to 10^{-8} cm/s. Calculation of the air-filled porosity of the test soil gave a number of about 15 percent. It has been concluded that soil with adequate air-filled porosity is amenable to VOC removal by vacuum extraction regardless of its permeability.

Correlative Results of the Demonstration

Correlation of Declining VOC Recovery Rates with Time

VOC recovery rates showed a steady decline with time and the data points correlated well with the use of an exponential equation of the form $y = ae^{-kx}$, where y is the concentration of contaminant in the extracted vapors and x is time. This type of an equation is generally used to represent an unsteady state process such as vacuum extraction.
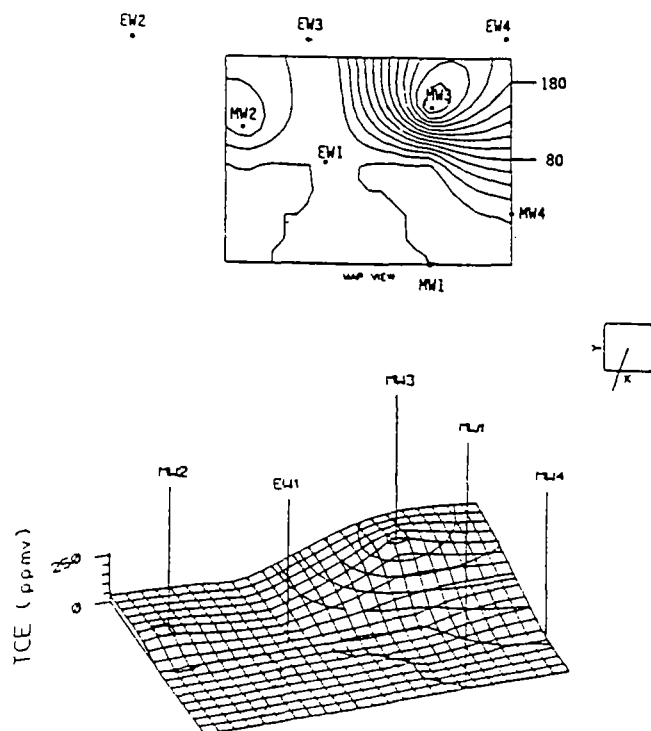

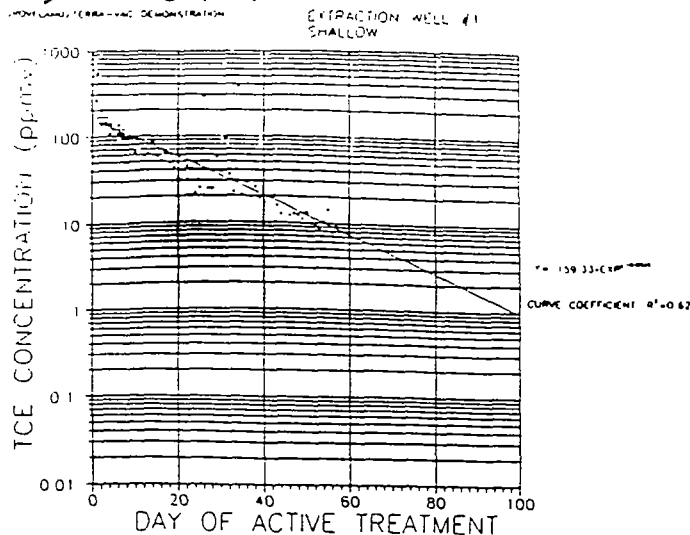Figure 4.   Post-treatment shallow soil gas concentration.

Figure 5. Wellhead TCE concentration vs. time.

As shown in Figure 5, done for the shallow extraction well number 1 (EW1), the logarithm of the TCE concentration in the wellhead gas versus time shows a good correlation when a least-square's best-fit line was drawn through the majority of data points. Such graphs were constructed for all extraction wells.

From the graph in Figure 5, one can estimate the time needed to achieve nondetectable levels of TCE in the wellhead gas, which would be 250 days. This graph alone cannot be used to predict well the time needed to achieve the desired concentration of TCE in soil. However, it can be used as one of the steps in predicting the time needed for site remediation.

Prediction of VOC Concentration in Soil from VOC Concentration in Wellhead Gas

As shown in Table VI, VOC concentrations in the soil calculated from VOC concentrations in wellhead gas with the use of empirically derived Henry's constants are not in good agreement with the actually measured VOC concentrations in the soil. Thus, correlation of VOC concentration in the wellhead gas with the VOC concentration in soil with the use of simple calculation was not achieved in this project. However, it is useful to have a set of data that shows the concentration of VOC in the wellhead gas and the corresponding VOC concentration in the soil in the vicinity of this well at the same time. Such data can be used as one of the steps in predicting the time needed for site remediation.

Prediction of Time Required for Site Remediation

Absolute confirmation of the achievement of the site remediation with the use vacuum extraction can be done with analysis of soil after the process is stopped. Since such tests are expensive and time consuming, it is useful to make some estimation of the time needed for site remediation.

In this project, an approach was developed that can be useful in making rough estimates of time needed for site remediation. This approach uses a multi-step calculation requiring the following inputs:

- preliminary data and established relationships from operating vacuum extraction at the site;
- estimate of the amount of contaminated soil at the site;
- knowledge of the physical and chemical properties of the contaminant and of the basic soil characteristics at the site;
- knowledge of site geology;
- use of two mathematical models: a Vertical and Horizontal Spread (VHS) model and an Organic Leachate Model (OLM). A complete discussion of the VHS model can be found in the November 27, 1985 Federal Register. A revised version of the OLM model is presented in the July 29, 1986 Federal Register.

These mathematical models allow the use of a regulatory standard for a given contaminant in drinking water, a compliance point in the model, to arrive at a target concentration of this contaminant in the soil. The regulatory standard for TCE in drinking water is 3.2 parts per billion. The general outline of this approach is to calculate the wellhead gas concentration corresponding to the determined allowable soil concentration from the ratio of measured wellhead gas concentration to the determined soil concentration. Achievement of the calculated wellhead gas concentration by operating the process would indicate achievement of the target soil concentration. Calculation is done in steps.

Step 1—The VHS model is used to calculate the concentration of VOC at a compliance point C_y from:

$$C_y = C_o \, \text{erf} \, \{Z/[2(a_z Y)0.5]\}$$
$$\times \, \text{erf} \, [X/(a_z Y)^{0.5}]$$

Table V. **Monitoring well number 3 (MW3)**: TCE reduction in soil strata.

Depth ft.	Description of strata	Permeability cm/s	TCE concentration mg/kg (ppm)	
			Pre-test	Post-test
0–2	M. stiff brn. fine sand	10^{-5}	10.30	ND
2–4	M. stiff grey fine sand	10^{-5}	8.33	800.0
2–6	Soft lt. brn. fine sand	10^{-4}	80.0	84.0
6–8	Lt. brn. fine sand	10^{-4}	160.0	ND
8–10	Stiff V. fine brn. silty sand	10^{-4}	ND	63.0
10–12	Silty sand	10^{-4}	ND	2.3
12–14	Soft brown silt	10^{-4}	316.0	ND
14–16	Wet green-brown silty clay	10^{-3}	195.0	ND
16–18	Wet green-brown silty clay	10^{-8}	218.0	62.0
18–20	Wet green-brown silty clay	10^{-3}	1570.0	2.4
20–22	Silt, gravel, and rock frag.	10^{-4}	106.0	ND
22–24	M. stiff lt. brn. med. sand.	10^{-4}	64.1	ND

Table VI. Comparison of wellhead gas VOC concentration and soil VOC concentration.

Extraction well	TCE conc. in wellhead gas (ppmv)	TCE conc. in soil (ppmv)	TCE conc. in soil predicted by Henry's Law (ppmw)
EW1 shallow	9.7	54.5	0.11
EW1 deep	5.6	7.2	0.07
EW2 shallow	16.4	ND	0.20
EW2 deep	14.4	20.4	0.17
EW3 shallow	125.0	20.9	1.53
EW3 deep	58.7	18.0	0.74
EW4 shallow	1,095.6	9.1	12.49

where:

C_y = concentration of VOC at compliance point (mg/L)

C_o = concentration of VOC in leachate (mg/L)

erf = error function (dimensionless)

Z = penetration depth of leachate into the aquifer

Y = distance from site to compliance point (m)

X = length of site measured perpendicular to the direction of groundwater flow (m)

a_t = lateral transverse dispersivity (m)

a_z = vertical dispersivity (m)

A simplified version of the VHS model is most often used, which reduces the above equation to:

$$C_y = C_o C_f$$

where:

C_f = erf $\{Z/[2(a_z Y)^{0.5}]\}$ erf $[X/(a_t Y)^{0.5}]$, which is reduced to a conversion factor corresponding to the amount of contaminated soil

Step 2—The OLM model is used to calculate the target concentration of VOC in soil C_s from:

$$C_o = 0.00211\, C_s^{0.678} S^{0.373}$$

where:

C_o = concentration of VOC in leachate (mg/L)

C_s = concentration of VOC in soil ~~(mg/L)~~ (mg/kg)

S = solubility of VOC in water (mg/L)

The calculated target TCE concentration level in soil at Groveland site was 500 parts per billion.

Step 3—Site specific data, such as is shown in Table VI, is used to calculate the required wellhead gas concentration that would correspond to the target VOC concentration in soil. With the use of Table VI, if the calculated TCE concentration in soil is 500 parts per billion, then in the shallow extraction well number 1, (EW1 shallow), the well-head gas concentration would be 88.99 parts per billion.

Step 4—Site specific data, such as shown in Figure 5, is used to calculate the time required to achieve the wellhead gas VOC concentration that corresponds to the target VOC concentration in soil. In this example, with the use of Figure 5, the time needed to achieve the TCE concentration in the wellhead gas of EW1 shallow of 88.99 parts per billion would be about 150 days.

The above approach of predicting the time needed for site remediation is only one of many other approaches that can be used. However, regardless of the approach used, the vacuum extraction should be stopped and restarted several times before the soil sampling is done. The time intervals between these stops can be again calculated from mathematical diffusion models that are applicable to the specific site. It is reasonable to believe, that if no increase in the wellhead gas concentration is measured, than the soil has reached its residual equilibrium concentration. This residual equilibrium concentration of contaminants in soil should be less than the target soil concentration.

Observation of the Operation of the Terra Vac System in Groveland

The Terra Vac system operation was very reliable under the adverse weather conditions of the New England winter and required minimal attention. Actually, this process can be operated unattended for days with just a periodic check of the vapor treatment system to confirm that no VOCs are emitted to the atmosphere. Placement of the vapor treatment system in the vacuum line before the vacuum pump assures that no VOCs escape to the air in case of a leak in the vacuum line. In case of a power failure, the system would be stopped without a potential for VOCs to escape. Noise from the blower can be reduced with insulating panels around it, and this needs to be done only if the system operates very close to residential area.

Silting-out of an extraction well was the only operational problem seen, and this can be corrected easily by installing another well nearby. The system is very flexible, and any modifications can be done very easily.

Notes on Economics

The vacuum extraction technology offers an economical option to remediate sites contaminated with volatile organics. Even when a contaminated site contains other contaminants, such as heavy metals, in addition to VOCs and semivolatiles, it may still be economical to first remove the VOCs with vacuum extraction and then utilize other technologies for complete remediation of the site.

The economics of this process strongly depend on whether vapor treatment is required and whether any wastewater is generated at a site. Based on available data, the process costs between $10 to $150 per ton of remediated soil. When no vapor treatment is required and no wastewater is generated, the remediation cost can be even less than $10 per ton. The result of the EPA economic analysis of the Terra Vac process shows a cost-per-ton range of $27 to $66 (see Reference 2).

In the SITE project 15,200 lb of activated carbon was used and 17,000 gal of wastewater was extracted from soil. The activated carbon was returned to the manufacturer for regeneration and the wastewater hauled to a permitted biological disposal facility. In a full-scale application of vacuum extraction, both the regeneration of activated carbon and treatment of wastewater would be carefully planned and probably done on site.

Utilities requirements for the process are very low and usually do not exceed 1 percent of the total remediation costs.

Conclusions

The following conclusions are drawn from examining data obtained from the eight-week SITE demonstration of the Terra Vac system in Groveland:

- The process represents a viable technology with a promise to fully remediate site soils contaminated with volatile organic compounds.
- In eight weeks of operation, the process extracted a significant amount of VOCs (1,300 lb) and achieved non-detectable levels of

$$C_s = 8866\, C_o^{1.47} / S_4^{0.550}$$

VOCs at some locations of the tested area.

- Ninety-five percent reduction of VOC concentration in the soil gas was achieved in the course of the demonstration.

The process demonstrated good performance in **removing** VOCs from soil with **measured permeability ranging from 10^{-3} to 10^{-8} cm/s**. It appears that the process works well with a variety of soils and under a broad range of geological conditions.

- Good correlation was achieved between the VOC recovery rates and time.
- Operation of the system was very reliable.
- The process is economical.

Notice

The project described in this paper has been funded by the U.S. Environmental Protection Agency under Contract No. 68-03-3255 and the Superfund Innovative Technology Evaluation (SITE) Program. Mention of trade names or commercial products does not constitute an endorsement or recommendation for use.

Acknowledgments

References

1. Technology Evaluation Report from SITE Program Demonstration "Terra Vac In Situ Vacuum Extraction System, Groveland, Massachusetts," U.S. Environmental Protection Agency, EPA/540/5-89/003, May 1989.
2. SITE Program Applications Analysis Report "Terra Vac In Situ Vacuum Extraction System," U.S. Environmental Protection Agency, Draft report.

Mary K. Stinson is a Physical Scientist with the Releases Control Branch of the Risk Reduction Engineering Laboratory, Environmental Protection Agency, Edison, NJ 08837. This paper was submitted for peer review on June 1, 1989. The revised manuscript was received July 7, 1989.

ATTACHMENT III

SUPERFUND CONSTRUCTION COSTS
Rising costs prompt Army Corps, industry studies

EPA has asked the Army Corps of Engineers to ex-
plain why construction bids are going up, and industry and
the Dept. of Energy have commissioned a study that would
give a clearer picture of what cleanup liabilities really are.
In a series of stories, *Superfund Report* looks at construc-
tion costs, beginning with the recent jump in bid prices for
Superfund construction contracts, which has resulted in a
Corps of Engineers investigation of what may be causing
the price hikes (page 2).

Responsible parties should expect to pay more than es-
timates indicate, as real costs of Superfund construction
projects exceed estimates by 50%, according to prelimi-
nary results of a study financed by industry and the Dept. of
Energy (page 2).

And EPA wants to avoid paying more than it should for
basic construction services, prompting agency plans to
downplay the Superfund connection in future requests for
construction bids for projects that do not involve dealing
with hazardous waste (page 10).

Newswatch

end up costing ... tion contrac ... about ?

CLEANUP COSTS — Unexpected Increases prompts Army Corps probe

A jump in Superfund construction costs has prompted an Army Corps of Engineers investigation into what may be causing the price hikes, with the Corps trying to determine what role contractor financial guarantees may play in pushing up prices. The Corps investigation is being carried out at EPA's request.

Suspicion at this point is focused on construction bonds, according to some EPA and Corps officials, who say that difficulty in obtaining bonds may be limiting competition, with the limited competition spurring higher costs. Another Corps source said the actual cost of bonds for hazardous waste work may be the source of the higher costs. The source said bond costs were reportedly running from 5% to as high as 20% for Superfund construction projects, versus about 1.5% for non-Superfund construction projects. But a surety industry source said bonds for Superfund construction contracts cost from 3% to 5% of the contract value.

As part of its contracting process, the Corps routinely estimates what a given project should cost. Officials became alarmed toward the end of FY-1989 when it became apparent that a lot of contract bids were coming in higher than the Corps had estimated. A Corps official said that in the past, Corps estimates were generally in the middle of the range of bids received. But last year, the official said, the Corps estimates began to slip towards the low end of received bids, indicating that costs are going up. Corps and EPA officials all agreed that costs are a good bit higher than expected, but declined to provide actual numbers.

Several possible explanations for the cost increases were suggested by Corps and EPA officials, including the bonding difficulties described above. Also mentioned were the possibility that the higher costs are a result of using new technologies, or that the increases result from the increased demand generated during the spurt of remedial action starts late in the last fiscal year.

(In order to meet a statutory requirement that the agency begin 175 new remedial actions by Oct. 17, 1989, EPA had to sign a large number of contracts late in the fiscal year. This sudden spurt of construction procurement may have resulted in higher costs due to the increased demand.)

But the focus of current investigations is the bonding question. EPA has asked the Corps to carry out a study of if and how bonding difficulties are affecting the cost of remedial action. The results of the study are expected by the end of January. - Robert Harrelson

COST PROJECTIONS — Real liability greatly exceeds estimates, study shows

Responsible parties should expect to pay much more for Superfund cleanups than is usually estimated, according to early results of a study financed by industry and the Dept. of Energy. The report shows that cost estimates for remedial action projects are highly inaccurate, with real costs exceeding projections by 50%.

These results have implications throughout the Superfund program: responsible parties liability is greater than they may think; Superfund settlements may not be netting the agency sufficient funds to actually pay for cleanups; and the Superfund budgeting process may not be reserving enough money to pay for planned fund-lead activities.

The remarkable thing about the preliminary study results, according to the researchers is the continuing high levels of uncertainty all the way through the contracting process. For non-hazardous waste construction projects it is generally possible to estimate costs to within a few percentage points at the time of the contract award, sources say.

In a related development, EPA has asked the Corps of Engineers to look at why recent construction contract bids are coming in higher than expected (see related story above).

First results of the study indicate that real cleanup costs average 31% more than contract amounts, according to the researchers, while the mean cost growth (the amount by which real costs surpass estimates) is about 50% at the remedial investigation/feasibility study and the record of decision stages.

This means that, on average, a remedial action that is estimated to cost $10-million at the time the RI/FS is done will

Also in Newswatch...

4 9   0413

end up costing 50% more, or $15-million. By the time construction contracts are awarded, the average cost overrun is running about 31% ($13.1-million real cost for a $10-million contract).

Cost overruns are also the focus of a project underway within EPA's Office of Waste Programs Enforcement (OWPE). OWPE is working on a database that agency officials say will be used to calculate premium payments for Superfund settlements. The premiums are intended to cover costs in excess of the amount of the settlement, resulting either from overruns or from a need to do more work at a site. The OWPE database is in place, according to agency officials, but is not yet operational

(see *Superfund Report*, Oct. 11, p. 2).

Reasons for the identified construction cost overruns are unclear — one of the purposes of the study is to look at why this is happening — but the researchers suspect that the use of innovative technologies is a contributing factor.

The study is being conducted by Independent Project Analysis (IPA), a private firm under contract to a consortium of major companies, with substantial funding also coming from the Dept. of Energy. IPA researchers say the study sponsors are anxious to gain a better understanding of just what their real liabilities may be.

CONTRACTOR CONFLICT OF INTEREST — Industry sees snag for EPA policy

EPA's new conflict of interest policy, scheduled for release in early 1990, may be held up because of inconsistencies with a government-wide policy under preparation by the Office of Management & Budget, according to an industry source. But an EPA official discounted this, saying there are unlikely to be any major differences in the two policies, and the agency expects to release the policy in January as planned.

The industry source cited several aspects of EPA's proposed policy that he said would violate the OMB plan, including the definition of what constitutes a conflict of interest. Other inconsistencies cited by the source were the scope of the policy (EPA's policy would apply to the provision of basic engineering services, for example, while OMB's would not) and the way the policy would be implemented.

The EPA official said the agency policy would not be inconsistent with the OMB plan, but said EPA may go further than OMB. The official said OMB's policy would serve as a government-wide "baseline," setting a minimum standard that must be met by all federal agencies, but said EPA is free to go beyond what is required by OMB in order to protect the Superfund program.

The OMB plan, entitled "Policy Letter on Consultants and Conflicts of Interest," is presently in final draft form, with publication in the Federal Register expected soon.

Also unclear is the extent to which EPA has taken into account the OMB policy in developing its own conflict of interest plan. An EPA official said the agency has been aware of and has considered the OMB plan all along, but an industry source says it was only last week that the agency became aware of the possible conflict with the OMB policy.

The 1989 Defense Department Appropriations bill required OMB to develop government-wide standards on conflicts of interest for consultants working for the government, as well as procedures for promoting compliance with the standards.

Conflict of interest in the Superfund program has recently been the subject of congressional hearings, a General Accounting Office report, and internal EPA reviews.

One EPA plan for dealing with conflicts has already been implemented. Under that plan, Superfund response contractors

are barred from doing work related to policy development. But several sources in the contractor community have indicated they are more concerned by the restrictions placed on Superfund contractors wishing to work for potentially responsible parties.

Among the general proposals contained in the draft EPA policy are the following:

* Existing contracts will be modified to conform with the new policy by Sept. 30, 1990.

* EPA contracting officers will be required to document decisions related to conflict of interest determinations.

* Contractors who receive EPA work assignments will be required to certify that no conflict of interest will arise based on the assignment.

* New Superfund contractors will be required to submit a conflict of interest avoidance plan to EPA for approval.

* Contractors will be required to submit lists of all their clients, for use by EPA in determining if a conflict exists.

COST MANAGEMENT — OMB targets potential Superfund fraud, waste

The White House and a key congressman have targeted 73 government programs, including EPA's $8.5-billion Superfund program, as vulnerable to fraud, waste and abuse, in a move sparked by the Bush Administration to head off future scandals of the type that shook the Dept. of Housing & Urban Development earlier this year.

The "high-risk list," compiled by White House Office of Management & Budget Director Richard Darman and made public by Senate Government Operations Committee chairman John Glenn (D-OH), seeks controls on Superfund costs and expenditures through such methods as tighter contractor oversight and accounting procedures.

"These lists represent the smoke behind which a fire may be raging," Glenn said. "When the Inspector General of HUD reported similar problems in past years, insufficient notice was taken by both the Administration and the Congress, and a scandal erupted. We must make sure these warning signs are heeded."

Considered "high risk" by OMB were Superfund contracts management, property management and Trust Fund

financial audits. The OMB list said, "Superfund Trust Fund audits have reported that many accounts receivable in the Superfund program are not recorded until after receipt of checks. A recent Inspector General review identified $8-million of such accounts in one regional office."

A letter by Darman to high-level agency officials last August emphasized the need for EPA to "put controls in place to insure the integrity of the program" through better management of agency spending. The letter also acknowledged OMB's concern with EPA's financial management computer system, 5 instances of agency noncompliance with General Accounting Office accounting standards and more than 200 internal agency weaknesses. Furthermore, according to Sen. David Pryor (D-AR), EPA's alleged failure to exercise adequate oversight of its Superfund contractors could lead to conflicts of interest.

Darman acknowledged the likelihood of full-blown mismanagement scandals at agencies other than HUD at a hearing earlier this fall.

CONTRACTOR LIABILITY — Industry group denounces EPA policy

A waste treatment industry group strongly opposes EPA's proposed policy on contractor indemnification, saying the policy fails to protect private firms while at the same time inadequately protecting the public by providing no sure source of payment for botched cleanups. In a summary of the group's comments, which are presently in draft form, the group says that EPA's overriding objective under the new policy is to avoid liability for pollution arising from Superfund cleanups.

The comments are being prepared by the Hazardous Waste Action Coalition (HWAC) in response to guidance on contractor indemnification proposed Oct. 31. (see *Superfund Report*, Nov. 8, p.5).

The group's comment summary finds nothing to praise in the EPA proposal, and points out what the association alleges are factual errors and inconsistencies with the Superfund law. All of this, according to HWAC, adds up to an indemnification proposal that "fails to meet SARA Section 119 objectives." Section 119 of the 1986 amendments to the Superfund law (SARA) authorized the President (who delegated the authority to EPA) to indemnify response action contractors (RACs) against liability for work done at Superfund sites, and required EPA to develop guidelines to carry out the indemnification provision. EPA has been operating under an interim policy, issued in 1987, which would be replaced by the proposed policy.

HWAC charges in its comments that the effect of the policy will be to place most of the liability burden on RACs, despite what HWAC describes as EPA assertions that "the proposed guidelines are designed to protect RACs from liability while fulfilling other public policy goals."

Some of HWAC's concerns are:

Deductibles: HWAC says the deductibles proposed in the guidelines are "punitive," and that they will "force contractors to assume high levels of uninsured risk."

The proposed guidelines allow variable deductions for different types of contracts. Of concern to HWAC is the fact that the guidelines say the indemnification deductible is on a per occurrence basis. Thus, if a contractor has a deductible amount of $1-million, the contractor will be liable for the first $1-million of each claim. The total liability of the contractor is limited only by the number of claims.

Limits: HWAC says the proposed indemnification limits are inadequate given the risks posed by potentially large claims and multiple-site contracts.

The proposed guidelines set an indemnification limit of $50-million, with a minimum of $1-million, with the limit defined as a contract aggregate limit. Thus, for a given contract, EPA will make indemnification payments only up to the amount of the limit agreed upon, which cannot exceed $50-million, regardless of the number of claims.

HWAC also charges that EPA's guidelines contain "a number of startling inconsistencies or factual errors." Among them:

* HWAC says EPA's assertion that engineering firms are doing Superfund work without indemnification for the departments of Defense and Energy is wrong. HWAC says the congressional General Accounting Office has explicitly found that DOE and DOD contractors are indemnified under the Federal Acquisition Regulations.

* HWAC contrasts EPA's "admission" that indemnification has saved the government millions of dollars (that would have been spent reimbursing insurance payments) with the agency's apparent willingness, under the draft guidelines, to add to the cost of the Superfund program by beginning to pay for contractors' insurance.

* HWAC charges that the guidelines fail to look at the "nature and magnitude" of the risks facing contractors, "despite clear direction by Congress to do so."

* The proposed guidelines are in direct violation of the Federal Acquisition Regulations, says HWAC, because the proposal would have EPA add to the price supplied in a sealed bid, even though the added costs cannot be predicted.

The comment period on the EPA proposal closes Jan. 2. An HWAC official said the coalition's final comments will be submitted shortly before the deadline.